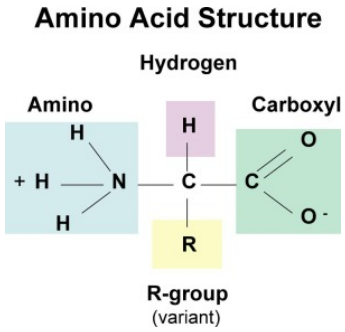
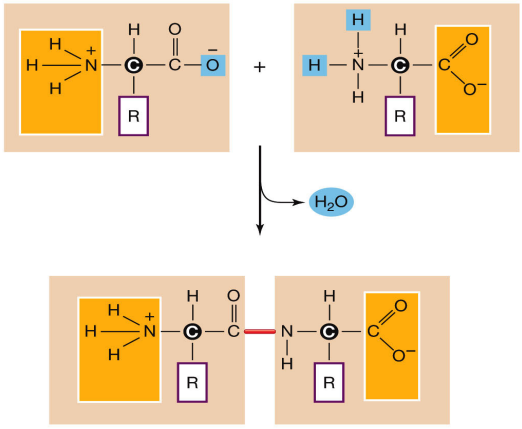
Week 1: Exercises with solutions

Chapters 3 and 5: Proteins, Carbohydrates and Cells

Question 1 (typical exam question, 1pt):
Draw the basic structure of an amino acid.



Question 2 (typical exam question, 1pt):
Draw the reaction leading to the formation of a peptide bond from free amino acids.



Question 3 (typical exam question, 1pt):
Could a disulphide bridge occur in the below peptide?

MAREDFVCAQEDCAASNDE

Yes: there are 2 cysteines, which could potentially join into a bond.

Question 4:
Define the concepts of primary, secondary, tertiary and quaternary protein structure.

1. The primary structure refers to amino acid sequence of the polypeptide chain
2. Secondary structure refers to highly regular local sub-structures. Two main types of secondary structure are the alpha helix and the beta strand. These secondary structures are defined by patterns of hydrogen bonds between the main-chain peptide groups. They have a regular geometry.
3. Tertiary structure refers to three-dimensional structure of a single protein molecule. The alpha-helices and beta-sheets are folded into a compact globule. The folding is driven by the non-specific hydrophobic interactions (the burial of hydrophobic residues from water), but the structure is stable only when the parts of a protein domain are locked into place by specific tertiary interactions, such as salt bridges, hydrogen bonds, and the tight packing of side chains and disulfide bonds. The disulfide bonds are extremely rare in cytosolic proteins, since the cytosol is generally a reducing environment.
4. Quaternary structure is a larger assembly of several protein molecules or polypeptide chains, usually called subunits in this context. The quaternary structure is stabilized by the same non-covalent interactions and disulfide bonds as the tertiary structure.

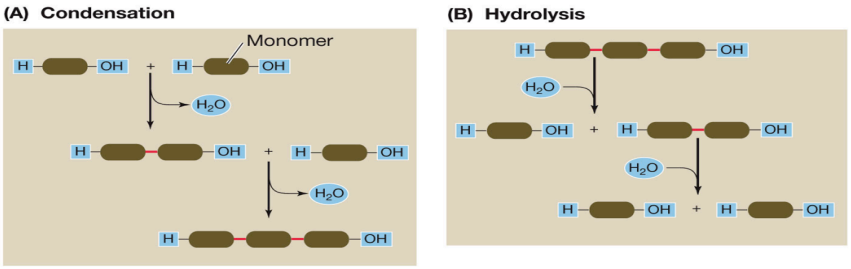
Question 5:
Describe the differences between an a-helix and a b-sheet.

*1. the **alpha helix (α-helix)** is a right-handed coiled or spiral conformation, in which every backbone N-H group donates a hydrogen bond to the backbone C=O group of the amino acid four residues earlier*
*2. Beta sheets consist of **beta strands** connected laterally by at least two or three backbone hydrogen bonds, forming a generally twisted, pleated sheet. A beta strand (also **β strand**) is a stretch of polypeptide chain typically 3 to 10 amino acids long with backbone in an almost fully extended conformation*

Question 6 (typical exam question, 1pt):
List a minimum of two conditions that can negatively affect protein structure.

1. *increases in temperature*
2. *alterations in pH*
3. *high concentrations of polar substances (Urea for example)*
4. *Nonpolar subtances*

Question 7 (typical exam question, 1pt):
Draw “hydrolysis” and “condensation” reactions.



LIFE 9e, Figure 3.4

Question 8 (typical exam question, 1pt):
Write the general formula of carbohydrates and list two main biochemical roles.

Formula: $C_n(H_2O)_n$
1. *They store energy*
2. *They can be used for transport of energy*
3. *They form carbon skeletons, useful to form new molecules*

Question 9 (typical exam question, 1pt):
Describe the structural differences between cellulose, starch and glycogen.

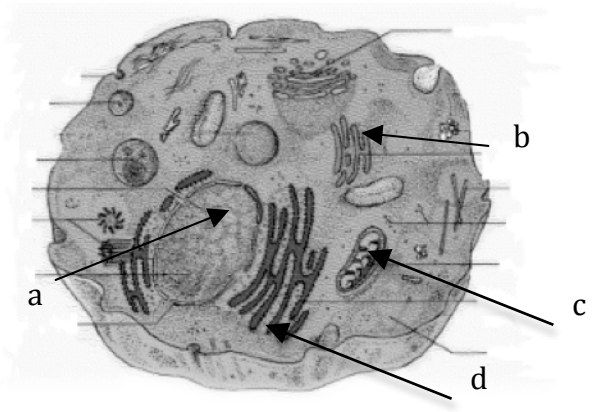
1. *Cellulose is a linear, unbranched polymer of glucose*
2. *Starch is a branched polymer of glucose*
3. *Glycogen is a heavily branched polymer of glucose*

Question 10 (typical exam question, 1pt):
Why is cellulose more stable than starch?

Cellulose is a polymer of monosaccharides connected exclusively by β-glycosidic linkage. This results in a higher chemical stability compared to the α-glycosidic linkages involved in starch and glycogen structures.

Question 11 (typical exam question, 1pt):
Mark the location of the following elements in the cell figure

A – Nucleus
B – Golgi
C – Mitochondrion
D – Endoplastic Reticulum



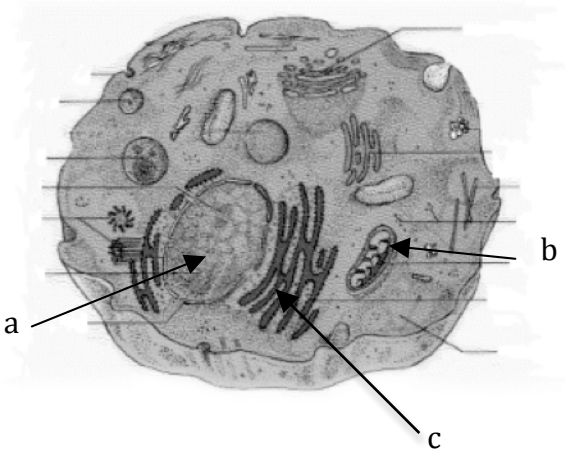
Question 12 (typical exam question, 1pt):
Describe the main differences between prokaryotes and eukaryotes.

Prokaryotes lack organelles, most importantly, nucleus, mitochondria, golgi, ER ect.

Question 13:
Describe the differences between animal and plant cells.

Plant cells have an extra cellular wall, a vacuole and chloroplasts (where photosynthesis takes place)

Question 14 (typical exam question, 1pt):
Mark the location where the following reaction/processes take place in the cell
A – DNA replication
B – ATP synthesis
C – Protein production



Question15 (typical exam question, 1pt):
What is the role of the Golgi apparatus?

It processes and packages proteins inside of the cell and before they make their way to their destination; it is particularly important in the processing of proteins for secretion.

Question 16:
Describe the functional differences of mitochondria and chloroplasts.

1. *The functional elements of chlorplasts are the tylakoids*
2. *The functional elements of mitochondria are the crests*
3. *Chloroplasts transform light (photons) into sugar/food*
4. *Mitochondria transform food/sigars into ATP (energy)*

Question 17:
Cells are very small. This is explained by the fact that the smaller the cell, the higher its surface-to-volume ratio is. Explain why is this an advantage compared to being bigger.

- Cell volume determines the need for resources and waste generation => chemical activity/time.
- Cell surface determines the amount of substances that can go into the cell (and the amount of waste that can leave it).
- A big area-to-volume ratio results in higher in/out flow vs lower need of resources and waste. Ideal conditions fro cell survival and efficiency.

Question 18 (typical exam question, 1pt):
Describe the roles of the smooth and the rough endoplasmic reticulum.

1. RER: protein synthesis and trafficking
2. SER: lipid and steroid synthesis; protein modification; chemical modification of small molecules

Question 19 (typical exam question, 1pt):
List at least four cellular components that are enclosed/surrounded by membranes.

1. *Mitochondria*
2. *Chloroplast*
3. *Nucleus*
4. *ER*
5. *Golgi*
6. *Lysosome*

Question 20 (typical exam question, 1pt):
What is the function of ribosomes?

Ribosomes synthesise proteins from mRNA and tRNA.

Question 21 (typical exam question, 1pt):
Name three amino acids that are typically found at the surface of integrated membrane proteins.

Hydrofobic amino acids - Alanine, Isoleucine, Leucine, Methionine, Phenylalanine, Tryptophane, Valine.

Question 22 (typical exam question, 1pt):
How many carbon atoms does a glucose molecule contain?

6.

Question 23 (typical exam question, 1pt):

What do you call the type of chemical reaction that leads to the generation of macromolecules, e.g., carbohydrates and polypeptides (proteins)?

Condensation.